

# Persistent Underwater Power Supply (PUPS) for Navy Applications



Deployment of Prototype

## Achievement

The Persistent Underwater Power Supply (PUPS) is a 2-electrode device co-invented at NRL consisting of an anode shallowly imbedded in marine sediment connected by external circuit to a cathode in overlying seawater. PUPS generates electrical power from oxidation of marine sediment organic matter with seawater. Presently configured, a PUPS consists of two 28.3-cm diameter ( $0.1829\text{-m}^2$  footprint area), 1.8-cm thick graphite disc electrodes positioned parallel to the seafloor and held  $\sim 46$  cm apart by a PVC tripod-frame. When lowered to sediment surface, the anode self-buries leaving the cathode exposed to overlying seawater. Single PUPSs have sustained 5.4 mWatt ( $45.7\text{ mWatt per m}^2$  footprint area) at 0.35 V for least 9 months without indication of depletion or fouling in shallow water coastal sites in New Jersey and Oregon. Two PUPSs connected in series have sustained 122 mWatt ( $335\text{ mWatt per m}^2$  footprint area) at 0.6 V for at least 6 months without indication of depletion or fouling. Numerous PUPSs have been operated periodically over the course of the past 35 months without indication of depletion or fouling. Ongoing laboratory experiments demonstrate the capability of increasing power generation of single PUPSs by 100-fold (up to  $4.6\text{ Watt/m}^2$  at 0.35 V) by electrochemical roughening of anodes with incorporation of known microbial oxidants (such as quinines). Ongoing laboratory and field experiments demonstrate the ability to increase power generation within a fixed footprint area by anodes composed of plates and spikes inserted into sediment perpendicular to the seafloor.

## Impact

An inherent weakness of all Navy high value battery-powered autonomous instrumentation is battery depletion resulting in interruption of operation and costly recovery and re-deployment. PUPS represents a energy harvesting technology capable of long-term (indefinite) power generation because it utilizes fuels and oxidants abundant in many marine environments that are locally replenished by natural processes and because it doesn't succumb to biofouling. When fully developed, PUPS will enable uninterrupted operation of a wide range of Navy autonomous instrumentation for periods of time well beyond that achievable by batteries resulting in substantial scientific, operational, logistic, and cost-reduction benefits.

## Primary Reference Documents

- "Harnessing microbially generated power on the seafloor" *Nature Biotechnology* 20 (8): 821-825, 2002

- “Electrode-reducing microorganisms that harvest energy from marine sediments” *Science* 295 (5554): 483-485, 2002
- “Harvesting energy from the marine sediment-water interface” *Environmental Science & Technology* 35 (1): 192-195, 2001
- “Method and Apparatus for Generating Power from voltage Gradients at Sediment-Water Interfaces” Patent Application filed 5/23/02, Navy Case number: 82,284. USPTO serial number: 10/148,104.

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